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DISTRIBUTION PATTERN OF ADULT LOCUST BORERS, (COLEOPTERA: CERAMBYCIDAE) ON NEARBY GOLDENROD, *SOLIDAGO* SPP. (ASTERACEAE), AT A FOREST-FIELD EDGE

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Abstract.—The occurrence of adult locust borers, *Megacyllene robiniae* Forster, was compared in transects and plots at 20 m intervals from forest edge into an old field that was dominated by flowering goldenrod, *Solidago* spp. Significantly greater numbers of borers were found near the forest edge than further into the field. Although mating was commonly observed on the goldenrod flowers, borers occurred singly per plant significantly more often than in groups.

The locust borer, *Megacyllene robiniae* Forster (Coleoptera: Cerambycidae), is a serious pest of the black locust tree, *Robinia pseudoacacia* L. (Fabaceae). Damage is caused mostly by the larvae, which mine in the sapwood and heartwood of the tree. Black locust is used extensively for strip-mine revegetation, mainly because it survives well under harsh conditions, on excavated and/or depleted soils (Boyce and Merz, 1959). The wood has long been valued for rot-resistance, and is in demand for fencing, planking and related uses (Cuno, 1930).

The locust borer is univoltine. Eggs are deposited on the rough bark of tree trunks from mid-August through mid-October. Hatching occurs in 8–10 days and the first instars bore into the inner bark, where they remain through the winter. Feeding activity resumes in the spring and larvae proceed through the cambium and sapwood into the heartwood. Pupation occurs within the larval mine, and adult emergence, mating, and oviposition occur in August and September. Discussions of the locust borer life cycle are presented by Hall (1942) and Garman (1916).

Control measures for use against the locust borer were summarized by Galford (1984). They include use of pesticides (Wollerman, 1955; St. George and Beal, 1932); site and silvicultural manipulation (Hopkins, 1908; Hall, 1942; Berry 1945; Wollerman, 1968; Harman et al., 1985a, b); and use of adult baits and attractants (Galford, 1977, 1979, 1980). At present, however, none of the available methods is considered practical in forest stands of black locust. Little published information is available on the movement and activity of adult locust borers. They are known to frequent the flowers of goldenrod, *Solidago* spp., where they feed on pollen and mate, and to return to black locust trees for oviposition (Hall, 1942). However, the pattern of movement and associated activities are poorly known. The objective of the present study was to determine the seasonal distribution

Table 1. Locust borer adults counted in transects, 200 × 2 meters, at varying distances from the wood's edge.

Distance from Wood's Edge (m)	Date of Count[2] Sept 10 Borers per Transect	Sept 20 Borers per Transect	Sept 30 Borers per Transect	Oct 10 Borers per Transect	Total Borers per Transect	Precent of Total
0	64	34	32	46	176	67%
20	19*	4*	24*	0*	47*	18%
40	8*	9*	11*	0	28*	11%
60	3	2*	6	0	11*	4%
Total	94	49	73	46	262	
Significance[1]	0.01	0.04	0.08	0.07	0.007	

[1] Pearson's R Test for correlation.
[2]* Denotes that the value is significantly different from the value immediately above it; Chi-square test for goodness-of-fit.

of adults on goldenrod at various distances from host trees.

Methods and Materials

The study was conducted near Frostburg, Maryland, in the Appalachian region, at an elevation of about 701 m. For a study site an 18 ha grove of black locusts was chosen that was infested by the locust borer and abutted an old field occupied predominantly by *Solidago* spp., mostly *Solidago altissima*. The site provided a distinct forest-field edge of more than 460 m. No locusts or other trees occurred in the field, but scattered black locusts occurred around the field perimeter on two additional sides.

Transects 2 m wide and 200 m long were established parallel to the forest edge, at 1 m, 20 m, 40 m and 60 m from the edge outward into the field. At 60 m the transect was in the approximate center of the field. In addition to the transects, circular plots, 2 m in diameter, were established at 1 m, 20 m, 40 m and 60 m from the forest edge into the field. Plots were included to provide a more detailed sample, particularly of the phenology of the goldenrod blossoms. The plot line was established at a randomly-selected point along the forest fringe, and the same plots were used on each sample date.

Transect and plot data were taken at 10-day intervals from September 10 through

Table 2. Number and percentage of *Solidago* plants in full bloom at 10-day intervals, September 10–October 10, 1984, at increasing distances from forest edge.[1,2,3]

Date	Plot 1 1 m Number	Plot 1 1 m Percent of Total	Plot 2 20 m Number	Plot 2 20 m Percent of Total	Plot 3 40 m Number	Plot 3 40 m Percent of Total	Plot 4 60 m Number	Plot 4 60 m Percent of Total	Percent of Total Total Number	Percent of Total Percent of Total
Sept 10	36	20	36	39	42	47	44	34	158	33
20	16*	9	12*	13	26*	29	18*	14	72*	15
30	8	5	24	26	8*	9	8*	6	48*	10
Oct 10	4	2	4*	4	0*	0	0*	0	8*	2
Total	64		76		77		70		286	

[1] Correlation analysis indicated no significant correlation between distance into field and number of goldenrods in full bloom.
[2] Plot distance from forest edge.
[3]* Denotes that the value is significantly different than the value immediately above it; Chi-square test for goodness-of-fit.

Table 3. Locust borer adults, counted in circular plots 2 meters in diameter, at varying distances from wood's edge.

Distance from Woods Edge (m)	Borers per Plot				
	Date of Count				
	Sept 10	Sept 20	Sept 30	Oct 10	Total
0	0	1	6	0	7
20	0	1	1	2	4
40	0	2	0	0	2
60	0	0	1	0	1
Total	0	4	8	2	14

Table 4. Frequency of groups of adult locust borers on goldenrod stems.

Distance from Wood's Edge (m)	Plants with One Borer per Stem	Plants with Two Borers per Stem	Plants with Three or More Borers per Stem	Total
0	95	30	5	130
20	21	8	2	31
40	19	4	0	23
60	9	1	0	10
Total	144	43	7	194

October 10, 1984. Transects were walked and the presence of locust borers was recorded, as was distance from the transect beginning point, and borer activity and location on the plants. The number of borers per goldenrod and occurrence of mating activity were also recorded.

In plots, all goldenrod plants were counted and maturity of flowers was recorded at each visit. Borers, if present, and their activity and location on the plants were recorded.

Weather during the period September 10–October 10 became cool, with onset of frost and periods during which weather conditions apparently inhibited borer activity and flowering of the goldenrod plants. On each of the observation dates, however, weather conditions, i.e. temperature, precipitation, and winds, were favorable and we observed insect movement among the goldenrod.

Statistical comparisons by data collection date were conducted using a Spearman Rank Correlation test for correlation between borer frequency and distance from the wood's edge.

Results

Borer adults per transect on each date are shown in Table 1. Borer concentrations were significantly greater ($P = 0.003$) in the transect nearest the wood's edge, decreasing farther into the field. This trend was consistent for each date and transect, except for September 20, when the 20 m transect yielded fewer insects than the 40 m transect. Borer numbers decreased over time, but varied possibly due to weather. The most noticeable difference in occurrence through the field was observed on the last study date, October 10, when borers were not encountered in the outer three transects (20 m, 40 m and 60 m), but were present in substantial numbers in the 1 m transect.

Numbers and percentages of blooming goldenrods in the plots are shown in Table 2. Collectively, the four plots provided a 483-plant sample. Percentages of fully blooming plants decreased progressively with each 10-day interval from September 10–October 10. The only exception was in plot 2 (20 m from wood's edge) where the percentage of fully blooming plants was greater on September 30 than on September 20. The data in Table 2 indicate that peak bloom was on or prior to September 10. Percentages of fully blooming plants varied from a maximum of 47% (plot 3, September 10) to 0% (plots 3 and 4, October 10). Too few borers were encountered in the 2 m circular plots for statistical analysis (Table 3). However, overall numbers were greatest near the wood's edge, as was the case in the transects.

The transect counts yielded a total of 194 borer sightings. Each sighting included all borers on a given *Solidago* plant. Borers per plant per sighting are shown by transect (Table 4) and sampling date (Table 5). Most sightings (144 of 195) were of one borer per plant (significance, $P = 0.001$). Two per plant

Table 5. Numbers of adult locust borers per goldenrod stem through the season.

Date	Plants with One Borer per Stem	Percent of Total	Plants with Two Borers per Stem	Percent of Total	Plants with Three or More Borers per Stem	Percent of Total	Total
Sept 10	49	71	18	26	2	3	69
Sept 20	39	89	5	11	0	0	44
Sept 30	43	77	10	18	3	5	56
Oct 10	13	50	10	38	3	11	26
Total	144		43		8		195

followed in frequency (43 of 195 sightings), but more than 2 per plant occurred only rarely (8 of 195 sightings). Of the latter, six were of 3 borers per plant, and two were of 5 borers per plant. Multiple occurrences (more than one borer per plant) were statistically more numerous in the transect nearest the forest edge ($P \leq 0.05$) than in the remaining three transects. Multiple occurrences were recorded on each study date, through October 10, and proportionally increased with the total count as the season progressed. The highest percentage of three or more borers per stem occurred on October 10. Both sightings of five borers per stem occurred on October 10. Despite these concentrations, no matings were recorded on October 10.

Discussion

The borer count of October 1 demonstrated that a substantial number of insects were still active at that time, after the onset of frost (mid-September) and the decline of much of the goldenrod bloom. The distinctly uneven borer distribution on October 10, with the 46 sightings in transect 1 nearest the forest fringe, and none in the other transects, was not explained. Possibly it reflected shorter flights, nearer the trees, and/or fewer surviving adults. The frequency and/or quality of blooming plants near the forest fringe could also have had an effect, although blooming plants still occurred in many parts of the field on October 10. No attempt was made to identify different species of flowering plants usable by the locust borer, but on one occasion during the study a locust borer adult was observed on a garden-growing sunflower *Helianthus annuus* L.

In a non-quantified observation, we noticed an apparent tendency by the borers to occupy goldenrod plants in full bloom, and seldom before and/or after. The sighting of a borer adult on goldenrods prior to blooming, or on faded or seeding flowers, was rare. Likewise, they appeared to be attracted to the more spectacular flowers in terms of brightness and size. Some clusters of isolated goldenrods outside the study area, disjunct from other goldenrods but near the black locusts, drew especially large numbers of borers (more than 10 per plant).

The tendency for the congregation of numerous borers per goldenrod plant appeared to be slight. One likely reason for this is that the pollen-feeding habit exposes the insects to predation. The flower-feeding habit probably led to the borer's mimicry, in elytral and abdominal color pattern, of stinging hymenopterans, implying the influence of predation. In this study the only instances of predation observed were by the garden spider *Argiope aurantia* Lucas, which was common. We observed 15 cases of locust borers killed and wrapped in webbing. No cases of avian or insect predation were observed, although the blooming flowers were visited by a large array of insects. No bird species appeared to be active in or around the field during data collection.

Our findings here offer some implications for control of the locust borer. Concentrations of the insects near forest-field edges could be the targets of limited chemical spray efforts during an exposed and vulnerable phase of the life cycle. The knowledge of likely concentration sites would also enhance controls utilizing manual and bait-trapping methods.

Literature Cited

Berry, F. H. 1945. Effect of site and the locust borer on plantations of black locust in the Duke Forest. J. For. 43: 751–754.

Boyce, S. G. and R. W. Merz. 1959. Tree species recommended for strip mine plantations in western Kentucky. USDA Forest Service. Central States Forest Exp. Stn. Tech. Paper 160. 13 pp.

Cuno, J. B. 1930. Utilization of black locust. USDA Circ. No. 131. 18 pp.

Galford, J. R. 1977. Evidence for a pheromone in the locust borer. USDA Forest Service. Research Note NE-240. 3 pp.

———. 1979. Preliminary test of booby-trapping for control of two cerambycids. USDA Forest Service. Research Note NE-284. 3 pp.

———. 1980. Use of a pheromone to cause copulation between two species of cerambycids. USDA Forest Service. Research Note NE-289. 2 pp.

———. 1984. The locust borer. USDA Forest Insect and Disease Leaflet 71. 6 pp.

Garman, H. 1916. The locust borer (*Cyllene robiniae*) and other enemies of the black locust. Ky. Agric. Exp. Stn. Bull. 29: 99–135.

Hall, R. L. 1942. Control of the locust borer. USDA Circ. 626. 19 pp.

Harman, D. M., P. Rudolf, and K. R. Dixon. 1985a. Influence of stand composition on locust borer (Coleoptera: Cerambycidae) attack rates. J. Entomol. Sci. 20: 207–211.

Harman, D. M., M. VanTyne, and W. A. Thompson. 1985b. Comparison of locust borer *Megacyllene robinia* Forster (Coleoptera: Cerambycidae) attacks on coal strip-mined lands and lands not mined. Ann. Entomol. Soc. Am. 78: 50–53.

Hopkins, A. D. 1907. The locust borer and methods for its control. U.S.D.A. Bur. Entomol. Circ. No. 83. 8 pp.

St. George, R. A. and J. A. Beal. 1932. New sprays effective in the control of the locust borer. J. Econ. Entomol. 25: 713–721.

Wollerman, E. H. 1955. Control of black locust insects by systemics. J. Econ. Entomol. 48: 760–761.

———. 1968. A Search for Borer-Resistant Black Locust. Pp. 53–54. *In* Proc. 6th Central States Forest Tree Impr. Conf.